Phys100: Exploring Physics:
The Foundations of Quantum Physics for Regular People

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> *"If you want to understand quantum mechanics, just do the math. All the words that are spun around it don't mean much."*—Freeman Dyson
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> *"There are no analogies or pictures by which to understand quantum mechanics."*—Richard Feynman
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> *"[Quantum mechanics is a] mysterious, confusing discipline, which none of us really understands but which we know how to use."*—Murray Gell-Mann
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> *"Those who are not shocked when they first come across quantum theory cannot possibly have understood it."*—Niels Bohr
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> *"The one thing that can be said against [quantum mechanics] is that it makes absolutely no sense!"*—Roger Penrose
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> *"Shut up and calculate!"—Richard Feynman or David Mermin?*
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> *"I think I can safely say that no one understands quantum mechanics."*—Richard Feynman
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> *"The best that most of us can hope to achieve in physics is simply to misunderstand at a deeper level"*—Wolfgang Pauli

Course Objectives and Expected Learning Outcomes:

In this class we will attempt the impossible—we will attempt to understand the conceptual foundations of quantum mechanics. To add to the difficulty (and fun!) we will do so without using any more mathematics than a regular person would understand. This is not to say that the ideas discussed will not require some effortful thinking and courage—this is often a scary and forbidding topic given its unprecedented nature and the machinery involved. But if you remove the machinery, think about things in a new way, and allow for some uncertainty and surprise, the "weirdness" of quantum mechanics melts but the fascination remains! As a class we will engage in this process to shed light on contemporary scientific culture, some modern technologies, and many enduring, interesting, and deep questions. For these reasons, understanding the ideas of quantum theory is becoming more and more of a necessity for the *true* "intellectual."

So if you'd like training on how to be a top-notch arm-chair theorist—exploring the big ideas of our most powerful theory while avoiding the difficulties (and accountability ☺) of mathematics—this class is for you!

> *"Like an adolescent reading Shakespeare, we feel the language of quantum phenomena to be at once strange and wonderful. The meanings are obscure, some words unknown. All the more reason to pause over it, to reread the text and muse over its possible meaning…Surely nature like a found dramatic script, deserves to be read for meaning and not merely acted out for profit…[E]verything depends on the courage and freshness of the reader."*—Arthur Zajonc

Course Text and Website:

For each topic covered in the class, a relevant reading from an accessible scientific article or popularized book will be posted on Canvas. Students are expected to check the Canvas course website frequently for these readings, announcements, discussion forums, and other resources.

In-Class:

In class we will discuss topics and apply reasoning in an interactive way—students will often be asked to offer opinions and make judgments. Your attendance and participation is therefore required as a lack of viewpoints can significantly stifle the discussion.

Out of Class:

Students are expected to read the selected materials prior to class and formulate questions, even if it does not all make sense. This will prepare students for the in-class discussions. The readings will also provide valuable additional information, depth, and context. An online discussion forum will be used for students to keep in-class discussions going and to react to each other and the readings. On this forum students will be expected to make *at least* three posts a week: one "Before Post" before class either reacting to the given prompt demonstrating preparation for class (due by noon Tuesday), one "After Post" responding to the previous class (due by noon Saturday), and *at least one* "Response Post" responding or reacting to another student's post (due by noon Tuesday). Additional credit can be given for *additional* "Response Posts" to make up for other posts that are missed or are weak.

In the End:

At the end of the course, students will submit a short paper (2 pages) reacting to and/or discussing one topic or aspect of the course. As students will often be asked to formulate their own opinions on some of the open topics we will discuss, the paper should be a reflection of the final sum of their thinking on a particular issue—they should take a position and present their (possibly personal) reasoning for taking it.

Attendance and Grading Policies:

- Participation (online posts): 5% per week for 70% of the final grade. The quality of the participation may be assessed as well.
    - 1% per week for a "Before Post" (i.e. a pre-class post)
    - 2% per week for a "After Post" (i.e. a post-class post)
    - 2% per week for an "Response Post" or Posts (i.e. responding to other students' posts)
- Final reflection paper: 30% of the final grade

Tentative Grading Scale: 90-100% A, 80-90% B, 70-80% C, 60-70% D, 0-60% F

Rice Honor Code:

All students will be expected to maintain the highest standards of honorable and ethical conduct by abiding by the Honor System at Rice University. http://students.rice.edu/students/Honor_System.asp

Students With Disabilities:

Any student with a documented disability should meet with Disability Services at Rice University to discuss appropriate accommodations. They should also let the instructor know as soon as possible about the situation, in accordance with Disability Services. https://dss.rice.edu

Tentative Schedule:

	Date	Topic
1	Jan 9	**The Nature of Science**: where metaphysics & epistemology meet
2	Jan 16	**Iconic Experiments**: when nature forces your hand
3	Jan 23	**The Postulates**: knowing the rules of the game
4	Jan 30	**Measurement**: finding answers and causing problems
5	Feb 6	**Complementarity**: discovering the dual nature of things
6	Feb 13	**Complex Systems**: what happens when you put things together?
7	Feb 20	**Decoherence**: making sense of the madness
8	Feb 27	**EPR**: Einstein's amazing mistake
9	Mar 6	**Bell's Theorem**: experimental metaphysics?!
11	Mar 20	**Competing Interpretations:** Bohr, Bohm, and Everett…
12	Mar 27	**Reality—Psi-Ontology & Contextuality**: …but are they really real?
13	Apr 3	**Applications—Quantum Biology, Cosmology, & Computing**: "nothing is more practical than a good theory"
14	Apr 10	**Wholeness:** harnessing the unity in matter
15	Apr 17	**The Bigger Picture**: does any of this *really* matter?

*Lectures 11-13 may be combined or replaced in order to make room for guest speakers, more detailed discussion, or impromptu topics.
**Spring Break occurs in week 10